

**NASA ADVISORY COUNCIL (NAC)
Exploration Committee**

MINUTES: Public Session

Meeting Date: April 26, 2011

AGENDA:

- Update on the Exploration Program
- Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era
- Global Exploration Roadmap
- Commercial Program Status

ATTENDING:

Exploration Committee:

Richard Kohrs (Chair), Bo Bejmuk (Co-Chair), Joe Cuzzupoli, Les Lyles, John Logsdon, David Longnecker, Carolyn Griner, Richard Malow, Bette Siegel (Acting Executive Secretary), Shawanda Robinson (Administrative Officer)

Members Absent: Nancy Ann Budden, John Logsdon, Les Lyles

NASA and Public Attendees: See detailed list, p. 14

OUTCOMES

FINDINGS:

Observation on Feasibility of Developing SLS by 2016

OBSERVATION:

The only feasible way of achieving initial heavy lift launch capability by 2016, is by using the reference design block approach to development of Space Launch System (SLS) and to initiate procurement actions promptly. Carefully planned evolution from Block 1 to Block 2 and ultimately to 130MT+ Block 3 is required to ensure cost effective transition through these Blocks while minimizing overall cost of SLS Program.

RECOMMENDATION (1):

NASA should engage a competent integration contractor immediately in order to define induced environments (loads, vibro-acoustics, and thermal) and propulsion system parameters (propellant flow rates, engine pressure requirements, and required ullage pressures) that envelope design conditions for all 3 Blocks. These enveloped design conditions then can be used to size flight hardware that can be common to all 3 Blocks.

RATIONALE (1):

This approach will minimize expensive redesign and retest requirements as SLS progresses from Block 1, to Block 2, and Block 3.

CONSEQUENCE OF NO ACTION (1):

If this recommendation is not followed, there will be deficiency in timely definition of design data for SLS and Multi-Purpose Crew Vehicle (MPCV), resulting in increased change traffic and increased cost and schedule. Furthermore, if the enveloping of induced environments of all 3 Blocks is not accomplished very early in the design phase of Block 1, unnecessary and costly design changes and associated testing will be required as NASA transitions to Block 2 and 3.

RECOMMENDATION (2):

NASA should promptly start development of a new expendable main engine by a US contractor that will provide sufficient power to support a 130MT or a greater launch vehicle capability. This new engine must support a launch vehicle schedule consistent with the need of the 130MT launch vehicle schedule.

RATIONALE (2):

For the past 40 years, NASA has relied on the Space Shuttle Main Engines (SSME). Russia and other countries have developed main engines for their programs. New technologies and personnel resources as well as higher thrust main engine requirements are needed

CONSEQUENCE OF NO ACTION (2):

The US could potentially lose its leadership in space exploration.

RECOMMENDATION (3):

The Committee strongly urges that NASA work expeditiously and visibly to ensure that the industrial base supporting engine production and development is sustained and enhanced.

RATIONALE (3):

Financial support of this activity has become time critical—especially given the cancellation of the Constellation program and the end of the shuttle era.

CONSEQUENCE OF NO ACTION (3):

Without NASA's attention to this matter, the engine workforce and knowledge base could slowly decline to a point of being unable to develop new leading edge U.S. engine technology.

FINDINGS:

Observation on the Decadal Survey on Biological and Physical Sciences presented by Elizabeth (Betsy) R. Cantwell of the Lawrence Livermore National Laboratory and Wendy M. Kohrt of the University of Colorado.

OBSERVATION:

The Committee received a briefing on the Decadal Survey on Biological and Physical Sciences presented by Elizabeth (Betsy) R. Cantwell of the Lawrence Livermore National Laboratory and Wendy M. Kohrt of the University of Colorado. The Committee was impressed by the scope, depth and value of this extensive and detailed analysis of the state of the biological and physical sciences in space, and within NASA in particular.

The Committee noted especially the value of table 13.2 in the study, which identified recommended research priorities for the physical and life sciences for each of eight strategic priorities that might form the basis for additional research in these areas. In essence, this matrix provides a “road map” for research that is guided by strategy, a particularly helpful approach that could inform both broad policy decisions and specific action agendas for funding agencies, NASA and related governmental agencies. The Committee also noted that radiation did not receive a prominence in the report because the study specifically pointed out that radiation had received detailed attention in separate reports prepared by the National Academies. Further, it noted that the study charter specifically excluded detailed budget planning from the purview of this study group.

RECOMMENDATION:

NASA should appoint an Associate Administrator for the Life and Physical Sciences, charged with appropriate responsibilities and authority to ensure that integrated, coordinated and sufficient approaches to these areas are achieved in order to support the needs for future human space exploration, and to foster science developments that further the nation’s role as a leader in space-related science.

RATIONALE:

The budgetary consequences of the Exploration Systems Architecture Study (ESAS) process had major negative consequences on the physical and life sciences, both within NASA and in the external research community, yet advances in these areas are essential for the future of human space exploration. The Committee endorses the content of the decadal report and wishes to specifically endorse the need for an integrated approach to research in the life and physical sciences within NASA, one that is supported by stable and sufficient funding that fosters advances not only within the agency but also within the external research community. In order to foster the necessary integration and emphasis within NASA, the Committee believes that a senior level administrator (i.e., AA) is needed to manage and represent the life and physical sciences initiatives within NASA.

CONSEQUENCE OF NO ACTION:

We will not have an integrated, coordinated approach to support human space exploration. In addition, we will not maintain the nation’s role as a leader in space related science.

FINDINGS:

NASA’s budget doesn’t support the Capabilities Architecture as currently defined without International and Inter-agency engagement. The initiative on the Global Exploration Roadmap is a good platform for these discussions. We encourage participants to continue these discussions and to begin to be more specific.

DISCUSSION

Update on the Exploration Program

Mr. Doug Cooke, Associate Administrator for the Exploration Systems Mission Directorate (ESMD), presented an update on the Exploration Program.

- Since the Authorization Act was signed ESMD has had extensive work to do for the integrated schedule and budget. NASA needs to begin identifying the reference design vehicle for MPCV and SLS.
- An Orion-like vehicle was chosen for MPCV, consistent with what was recommended in the Authorization Act and the in-house work.

- NASA awarded contracts to 13 U.S. companies to conduct six-month studies on heavy-lift launch vehicle based on industry data. The companies have been providing input and ideas on cost savings approaches; final out-brief is expected this week.
- Four teams were put together to work on the MPCV and the SLS. Three teams looked at competing configurations; all three teams looked at approaches to affordability. The fourth team looked at cross-cutting affordability, which has been a valuable learning tool.
- The reference design vehicle for SLS uses a block approach and is based on space shuttle/Ares derived hardware. The first team looked at this configuration and it is referred to as a LOX Hydrogen design.
- The second team looked at LOX kerosene propulsion. NASA would have to develop a LOX RP engine similar to what was used on Saturn V. With an upper stage it can reach 172mT capability.
- The third team is looking at components from the Delta IV and Atlas V using strapped-on solid rocket booster from existing programs.
- The first reference vehicle design (space shuttle/Ares), has a 70mT capability and would use a four-segment solid rocket booster, the same as the shuttle, but upgraded. It has a three-engine core stage, the same diameter and configuration as the shuttle; the 70mT capability would not have an upper stage.
- The second reference design vehicle has a 100mT level and would use two 5-segment boosters and switch to a core tank with three engines and an upper stage. A 130mT capability takes the same first stage with two 5-segment boosters, and five shuttle-derived engines, with the upper stage taking it to the 130mT capability.
- ESMD has done work on the MPCV in parallel with the Orion design specifically, and mapped the requirements from Orion and from the series of requirements in the Authorization Act. They are evaluating the contract to determine whether or not the contract scope can cover the MPCV requirements
- The team is evaluating the approaches of various commercial companies at the subcontractor level, to discover and understand their efficiencies. In addition, they are:
 - ◆ Looking at reviewing efforts to streamline the process to achieve higher efficiency
 - ◆ Looking at the testing philosophy and working through various cost saving measures.
 - ◆ Making evaluations from an integrated standpoint concerning the budget
 - ◆ Determining how to measure the progress on the MPCV in connection with SLS.
- Because of Constellation Program work on Orion, NASA is well advanced on the design of the MPCV and regrouping to develop the SLS. Mr. Kohrs wanted to know the status of the MPCV. Mr. Cooke responded that they (ESMD) have looked at the functionality of the vehicle itself, e.g., whether or not it is just a crew ascent and return vehicle; and the various ways to launch the MPCV. If we use commercial launch vehicles to launch, then a NASA HLV could be used to go beyond low Earth orbit (LEO); the total review is not yet completed.
- The integration activity is looking at the combined programmatic approach in terms of cost and schedule. Plans are being laid out for these approaches (i.e., how they lay out in number of years, and how we get through the cost).
- Mr. Bejmuk stated that it appears that MPCV development is probably a couple of years ahead of SLS. He then asked if they are converging simultaneously, and if the intent is to have them ready at the same time. Mr. Cooke responded that they have talked about whether or not to work to a certain point on one, and then to a certain point on the other. However, they both must come together at some point.
- NASA has to come up with a logical path to develop the SLS. There are many questions that NASA is trying to address (e.g., What is a logical path for developing new systems? What is the contractual approach?). There is a range of possibilities, such as using existing contracts instead of competing (may be leaning more towards full competition).
- Cost and schedule are important in knowing SLS option fits within the path. NASA must also be able to show that the program has value and is sustainable, with visible milestones and flight dates. NASA is making sure that it has a good understanding of what can be transitioned from the Space Shuttle and

Constellation Programs to the new programs. NASA must identify the current workforce skills and capabilities and determine how to apply them to future development. Other issues and concerns include the industrial base and supplies even at the lower level.

- Mr. Kohrs asked if the space suit contract would continue and if any contracts have been awarded on Ares V. Mr. Cooke answered that the suit contract would continue through the rest of the fiscal year and that NASA didn't have contracts specifically on Ares V.
- Mr. Bejmuk asked if it would be stretching the reality to say that a LOX RP engine would take longer to bring on board than option 1 which was based on shuttle-derived hardware. He then said that assuming it takes longer than three years, it would most likely increase cost of MPCV; not only the cost of the rocket but the cost of the capsule as well. Mr. Cooke replied that it would definitely increase the cost because the workforce would be carried longer, and that NASA is taking that all into account. It's too early to get to a final conclusion, and there are still have questions about what should be done. Other factors are:
 - ◆ The stakeholder's view of the strategy. The stakeholders are highly interested in what happens, including The Office of Management and Budget (OMB), the Office of Science and Technology Policy (OSTP), the Hill and the legislative offices and committees.
 - ◆ NASA is going to have a good solid story and an integrated approach including cost and schedule.
 - ◆ Factors include the Authorization Act and the Continuing Resolution (CR) language that added additional requirements. NASA is beginning to develop the strategy by gathering together the components of the heavy-lift vehicle studies.
 - ◆ As NASA works through the issues, it is making sure everyone is in agreement. ESMD is briefing OMB, OSTP and the Hill next week on the status of its program to keep its stakeholders informed. NASA intends to update the report it submitted to the Congress in the spring or early summer.
- Mr. Kohrs asked if the target date for the SLS is 2016. Mr. Cooke responded that NASA is trying to get a realistic date as soon as possible, as this will help in understanding the costs.
- Mr. Cuzzupoli said that 70mT vehicle may be reasonable if NASA doesn't re-compete everything. Mr. Cooke replied that NASA is working on understanding this through the reviews and analysis that will be taking place soon.
- Mr. Malow asked if NASA would potentially have to re-compete the booster core and was told yes, that is a possibility.
- Mr. Bejmuk asked if the development contracts be released in a couple of months or a couple of years. Mr. Cooke responded that it depends on whether or not there will be new competitions.
- Mr. Cooke stated that there are a couple other areas where progress has been made, such as Commercial Cargo and Crew. NASA awarded Commercial Crew Development 2 (CCDev 2) contracts last week. Another area being worked internally is the portion of the budget that is a combination of work done in technology. Some of the technology that remains in ESMD is unique to human space flight. NASA is planning to take advantage of the civil servants coming off the Space Shuttle and Constellation Programs (CxP); these are people already being supported and paid for and can address some of the follow-on work such as the SLS and MPCV. From this group of NASA employees that are available for new work, NASA will put together small teams to begin to develop and test concepts and systems. This model was used for Robonaut 2, in which a small group of people at Johnson Space Center (JSC), developed – in a partnership with General Motors Corporation (GMC) – Robonaut 2 at a very low cost. Another example of a prototype vehicle developed by a small team is the lunar electric rover. It was developed as a way to explore the moon in a pressurized rover. NASA is taking closer looks at concepts like suit ports. NASA is looking at doing a lot of work with small, in-house teams and is asking the NASA Centers to submit ideas.

- Mr. Cooke stated that the Human Research Program (HRP) is moving forward and is, to a large degree, the way it has been. It is on very stable path and is progressing.
- Mr. Cuzzupoli asked if anyone is working on future engine development? He was told there has been some work on the landers, such as landing engine vertical thrust, but nothing beyond that. He also asked if there are requirements for future engine development. Mr. Cooke replied that they have some requirements developed through the LOX RP team.

Recapturing a Future for Space Exploration: Life and Physical Sciences for a New Era

Dr. Elizabeth Cantwell presented the results of the Decadal Survey for Life and Physical Sciences

Discussion Points

- Decadal survey studies are common in the Science Mission Directorate and they help develop plans for the next decade of science. None of the decadal studies have been done on the exploration side of NASA. Congress requested this study and the NRC normally is required to produce a budgetary analysis but this time was instructed to not make any comments on budget.
- The purpose of the Decadal Study was to define research areas that:
 - ◆ Enable exploration missions
 - ◆ Are enabled by exploration missions
 - ◆ Define and prioritize an integrated life and physical sciences research portfolio and associated objectives
 - ◆ Develop a timeline for the next decade for these research objectives and identify dependencies between the objectives
- Mr. Kohrs asked if the HRP study was a part of the Decadal Survey. Dr. Cantwell said that yes, it was part of the study and that HRP has been funded for two decades. Also, as it is said repeatedly, if NASA wants to move the country forward in terms of space exploration, a new human exploration and integrated science program is necessary. The Decadal Study team received a lot of input from those that worked in this area in the past and have accomplished a great deal despite the uncertainty. Also, they have learned why the National Institutes of Health (NIH) came to believe they needed a separate program for Translational Medicine. NIH has had a Translational Medicine Program for a decade, and it is in this program that NIH seeks to ensure that basic research is translated to the patient level as rapidly as possible. The Decadal Survey advocates for the same concept for research in the Life and Physical Sciences so that basic research would get translated into missions. Two Decadal Survey panels had translational endpoints in mind. The rest of the Decadal panels worked on basic or applied research questions, but not how those research questions might get translated into missions. The Decadal survey had a panel that focused on human systems and one that focused on the hardware side of exploration.
- Mr. Kohrs asked if this was a two-year study. Dr. Cantwell replied that it took almost two and a half years and had 44 reviewers, which is the most for any study. Dr. Longnecker stated that this was partly due to the size of the document. Each reviewer was assigned to review specific subject matter. Dr. Cantwell replied that at least this aggregates the studies of each subject into one document. There is no better answer than to have an integrated research portfolio.
- Dr. Cantwell shared that each of the panels were asked to develop their recommended action for future research. Then the panels were asked to look at their research based on current infrastructure and what new infrastructure is needed. The International Space Station (ISS) is a critical part of the infrastructure.
- Mr. Cuzzupoli asked what the report suggested should be the interface to the National Lab? Dr. Cantwell said that the Request for Information (RFI) came out for National Lab after the study team was done with the report. The team was not asked and didn't overtly comment on the National Lab concept

or how it should be run. It did not address issues such as how NASA's research efforts should be organized, but everyone had a comment on how a program of this nature would be best constituted.

- Mr. Bejmuk stated that the budget of physical and life sciences was reduced by 50% after 2005 and that the scale (for the budget of Life and Physical Sciences) is somewhere between \$150 and \$180 million and that to provide an exact estimate would take more time and effort. Dr. Cantwell added that it is difficult to trace the budget because of several reorganizations that took place from 2005-2008; different parts of the program are in other divisions or other directorates. One example that can be somewhat traced is HRP, but others are in different portfolios.
- Dr. Kohrt stated that she did not plan ahead for the chapter on organization but the team got a lot of feedback from white papers and town hall meetings on this topic. Also, they decided to integrate all information from the various sources that they would like NASA to consider for developing a sound research program. One suggestion that the team received is that the solicitations need to be predictable so that researchers can put together a solid, high quality proposal.
- Mr. Bejmuk stated that Dr. Kohrt used the phrase "data confidentiality," and asked whom NASA is guarding data from. Dr. Kohrt replied that it is astronauts' medical data that is confidential; however, the researchers need it in order to understand the medical issues caused by spaceflight.
- Mr. Kohrs said that he thought that an Associate Administrator (AA) should manage this research.
- Dr. Longnecker stated that it appeared that the NASA/NIH renewal of the Memorandum of Understanding (MOU) is not going as well as expected. He then asked if comments on the basic science (with low Technology Readiness Level (TRL) or Countermeasures Readiness Level (CRL) will be included in the NASA portfolio according to the study teams., Dr. Kohrt answered that there are no specific recommendations about whether or not the NASA portfolio should include low CRL work.
- In reference to the Decadal Survey recommendation that "stable funding" be used, Mr. Malow said that "stable funding" is the right phrase to use because stability is more important than the amount. In addition, he said that this research has to have stable support inside the agency, so that it will not affect the community in a negative way and that he endorses the "stable" comment.
- Mr. Cooke said that money is being spent in areas that are high risk. Dr. Cantwell stated that the Office of the Chief Technologist (OCT) has programs that are addressing some of the high-risk areas.
- Mr. Bejmuk remarked that NASA spends quite a bit of money to operate the ISS and NASA spends much less on the science conducted on the ISS. He asked if the picture was getting better. Dr. Kohrt said that the team wants to beef up funding for science on ISS.
- Dr. Longnecker was surprised that radiation wasn't discussed. He thought radiation would be identified as a #1 showstopper and wondered whether the Decadal team didn't agree with this. Dr. Kohrt said that depending on policy, radiation can be a showstopper; but because there is already a very comprehensive report on radiation, it was not included in this report.
- Mr. Cooke recommended that Dr. Kohrt brief the full NASA Advisory Council on this report and that it should be briefed all the way up. He also said that it should stand for a long time and will be very helpful to NASA.
- Dr. Allen said that she is looking through the report because NASA has to respond to the Decadal Survey via the National Research Council (NRC) in June 2011.
- Mr. Malow stated that this was a little different than a typical Decadal Survey because Congress asked them to stay away from the budget. Typically this is a NASA-driven endeavor and the NASA community is supportive and willing to follow the study.
- Mr. Bejmuk asked if the report had been briefed to Congress. Dr. Cantwell stated that NASA briefed both OMB and OSTP. Also, that Chapter 13 does allude a little to budget and that there are a lot of cuts that came at the time of ESAS.
- Ms. Griner stated that if NASA's researchers don't have the expertise and are not familiar with what exploration is trying to do, then NASA can't get support for exploration. She also stated that these are

the types of things that need to be known and that there needs to be some foundation for exploration. This is very important work.

- Dr. Cantwell said it was time to raise the red flag and at least prioritize some of the research that is the perspective of the team that wrote this report. Dr. Kohrt stated that if you have a gap in a research stream, research proposals will not be at the level of sophistication needed when they are received.

Global Exploration Roadmap

Ms. Kathy Laurini briefed the committee on the Global Exploration Roadmap. The Roadmap is a tool developed by 14 space agencies to facilitate enhanced coordination and cooperation of global human space exploration activities. The Roadmap will evolve over time to see who develops what. It is a non-binding product of the International Space Exploration Coordination Group (ISEG). It can provide the technical basis for making policy and plans.

Discussion Points

- Ms. Laurini stated that ISECG is a group of 14 space agencies that thinks about technical feasibility and this is how they achieve common understanding for the purpose of forming partnerships.
- Mr. Bejmuk asked how frequently the chair rotates on this committee. Ms. Laurini stated that the rotation is every year. Non ISS partners can be chair ISECG if they request it.
- Mr. Cuzzupoli asked who besides Russia, that has been on the space station, isn't part of ISECG. Ms. Laurini replied that the Brazilians and the Saudis are not members.
- Mr. Cuzzupoli asked who isn't participating that has already been to the ISS? Ms. Laurini replied that everyone with a large amount of resources is on the list. Mr. Cooke stated that the Russians have participated but have not been very active until now.
- Mr. Cuzzupoli asked if there's anyone that's not in favor of working together to create a global plan. Ms. Laurini stated that China hasn't expressed an interest. The Indians have said yes, but it has been difficult to construct a plan that includes Indian participation. It is believed that the Indians have a limited number of experts, making it difficult to conduct effective discussions; however, they are very supportive of ISECG and have telegraphed that they want to collaborate.
- Mr. Cooke remarked that this group should begin to have discussions regarding the destinations and that they should begin coming to a consensus during this uncertain time.
- Ms. Laurini stated that there is still a lot of interest in the moon and that NASA has done study work looking for commonalities in goals and objectives while sharing insight into the work. It is not expected that all countries will have the same set of objectives. The thematic areas are captured; there is a global strategy for why they do this. The ISECG is making an attempt to group the objectives in a logical way.
- The ISECG supports the commercial crew and cargo transportation concepts that NASA has embraced. In addition, ISECG is talking about having commercial companies running space station (along the model of United Space Alliance). It doesn't make sense for the government to run the transportation service to LEO when these flights can be purchased, and the same might be true for ISS operations.
- Mr. Cooke was asked when ISS would get to a critical mass of information and research results and if in five years NASA would still be getting benefits from it? Also, at what point does NASA invest in the next steps?
- Mr. Bejmuk asked if NASA thought that the international partnership was helping to support exploration. Ms. Laurini replied that it was helping and that they trust that the partners know how to do cooperative programs since they have already worked well together on the ISS. Mr. Kohrs added that in some cases NASA is trusting the internationals more than the contractors. Ms. Laurini replied that it's because the international partners' people have worked on the ISS.
- Mr. Cooke thinks the participants they've seen are very enthusiastic about the participation in the Global Exploration Roadmap.

- Mr. Bejmuk remarked that potential exploration partners are interested in a contribution that gives them a long-term role so they can build the capabilities.
- Mr. Kohrs stated that NASA must get the partners and the State Department on board to get the MOUs. It took about three or four years for space station MOUs. Mr. Bejmuk said that when you see something like this you want to do a pilot run. Mr. Cooke said that he and Mr. Gerstenmaier have talked about trading, using station as a starting point for exploration.
- Mr. Bejmuk asked if there is any idea of what the cost might be if it were possible to travel to Mars today, or if we are afraid to know. He also asked if the numbers have ever been estimated? It was said that it is important to do this planning now, so that decision makers can make good decisions.
- Dr. Longnecker is interested in briefing the International Space Summit on this and thinks that it is a very interesting topic.

Status of the Commercial Space Transportation

Mr. Doug Cooke briefed the committee on the Commercial Programs

Discussion Points

- The Commercial Orbital Transportation Services' first and second quarter augmentation milestones have been negotiated, signed and completed by Orbital and SpaceX. The third and fourth quarter milestones are in work.
- On March 29, 2011, SpaceX briefed NASA Headquarters on combining Demo 2 and Demo 3 into one test. They have been making progress in all of these areas. Mr. Cooke said that the Russians are concerned with the safety of this approach; NASA is discussing the approach with them.
- All CCDev 1 Space Act Agreements have been completed. On April 18, 2011, NASA awarded four new Space Act Agreements as part of CCDev 2, to develop elements of the system, such as launch vehicles and spacecraft.
- Orbital has been testing the AJ26 engine, and plans to launch at Wallops, which has been working on launch pad construction.
- Paragon is working on components of the life support systems.
- CCDev 1 and 2 are Space Act Agreements. It has not been decided if Space Act Agreements will be used for CCDev 3.
- Mr. Kohrs asked if CCDev 3 will be an open competition? The answer he received was yes.
- Mr. Bejmuk asked if NASA intends to motivate the commercial companies to bring in more of their own money by having contracts with to follow the space act agreements, as NASA did with COTS? Mr. Cooke stated that it is a part of the philosophy. The following is what each company was awarded in CCDev 2:
 - ◆ Blue Origin - \$22 M
 - ◆ Boeing - approximately \$92 M
 - ◆ Sierra Nevada - \$80M
 - ◆ SpaceX - \$75M.
- Mr. Kohrs asked what the commercial companies are contributing? Mr. Cooke said that it was not a big percentage, and that he did not know the exact amount. There was some negotiation to make things fit within funding. There are paid milestones approaching that are specific to proposals. Diversity is included in the concept. All of the companies addressed safety.
- Blue Origin is working on a pusher escape system. It wants to mature the design and test the system. This is a relatively small investment on NASA's part. Boeing is working on the reusable CST 100, which is compatible with multiple launch vehicles. It has been working the programmatic path. This proposal will include Preliminary Design Review.

- Sierra Nevada Corporation is working on Dream Chaser, which is a reusable, piloted lifting body, derived from the NASA HL 20, to be launched on Atlas V. The goal is to mature the design through a Preliminary Design Review and some subsystems through a Critical Design Review.
- SpaceX is developing its crew transportation system based on the existing Falcon 9 launch vehicle and Dragon spacecraft. From their inception, both have been designed for crew carriage with relatively minimal modification. SpaceX is developing the longest-lead and most safety-critical system – the Launch Abort System. Mr. Cooke stated that much of the work that went into this project would be of use. The design of the launch abort system is using many components from the abort control motor.
- Mr. Kohrs asked if there would be wind tunnel tests. Mr. Cooke stated that Boeing was doing wind tunnel tests.
- A successful Commercial Crew Program will transform human spaceflight for future generations. It will be reliable, cost effective, and safe for crew transportation to the ISS and LEO. Mr. Bejmuk stated that this is what the Augustine committee recommended.
- Mr. Cuzzupoli asked how many seats were secured from Russia. Mr. Cooke was unsure, but said that he would get the information. He also stated that this was Mr. Gerstenmaier's approach is to have overlap with the Soyuz and Commercial Cargo/Crew.

Comments from the Public

There was no public comment at the end of the presentations.

General discussion from the Committee

- Mr. Bejmuk stated that there was no cost data provided for the different options developed for the SLS. Mr. Cooke said that they have initial cost data but he wants to understand it better before releasing it. They will have an independent cost estimation done and will continue that process long term.
- Mr. Kohrs said that the cost models have a great deal of complexity. Mr. Cooke stated yes, that is exactly why he wants to meet with the teams first.
- Mr. Cuzzupoli asked what the core is on the 70mT vehicle. Mr. Cooke stated that it is basically the components of an external tank derived from the shuttle.

NAC EC Discussion and Recommendations

- Mr. Bejmuk thinks that NASA is doing a good job on global/international engagement; however, he doesn't see any specifics such as the splitting up of tasks.
- Mr. Kohrs stated that he thinks it's too early for the partners to make specific agreements and that if he were another country's space agency, just knowing NASA's budget woes he would be hesitant to agree to anything until NASA gets it together.
- Mr. Bejmuk asked if the internationals think of America as a good partner or a flaky partner. Mr. Kohrs stated that it was lucky for us that the partners hung together even when the space station slipped. The Japanese put a lot of money into the ISS. The international partner contributions to ISS are what kept that program from being cancelled by Congress.
- Mr. Bejmuk feels that NASA should give ESMD accolades for working with the International Partners and encouraging them to start progressing to the next step. They now have two or three meetings a year. NASA needs to elevate this and move to make agreements.
- Ms. Griner said that she would like to see more science and technology objectives incorporated into the future program but NASA cannot fund this research on its own. It is a major accomplishment that they are still talking to the partners after all of NASA's changes in missions and rockets.

- Mr. Bejmuk said that it seems like it's time to start penciling in your country on this Global Exploration Roadmap to see if you have any takers to make specific agreements.
- Mr. Kohrs said that the Augustine Committee observation that the program is not affordable is based on a U.S.-only concept and that NASA needs the international and interagency partners. The NASA Advisory Council (NAC) can encourage NASA to turn up the heat to get agreements with interagency and international partners. Engagement and continued encouragement is essential and the Global Exploration Roadmap is a good way to foster it.
- Ms. Griner expressed there is no architecture for a large mission that the U.S. can fund on its own. There is not a combination of things that the U.S. can say they are going to go do. She thinks they should get an "atta boy" for just having these discussions.
- Mr. Kohrs stated that another immediate concern is looking at high thrust for the LOX RP engine.
- Mr. Cuzzupoli said that he wished that he had heard Ms. Laurini's briefing before that of Dr. Olson. He realized that NASA wasn't planning on doing the entire architecture alone but was working with partners on it. Although there is still a lot of work to do, he feels better about the work now.
- Mr. Bejmuk stated that to develop the engines based on the shuttle it will take about three years and therefore reduce the gap sooner.
- Mr. Cuzzupoli stated that it will take between five and seven years for NASA to develop a higher-thrust kerosene engine.
- Mr. Bejmuk stated that if you start an SLS rocket with three SSME instead of developing an expendable SSME, then you could develop a kerosene engine.
- Mr. Bejmuk said that he can't dream of flying anything near 2016 with LOX Kerosene and that the only thing you can come close to is four segments with three SSME.
- Ms. Griner's comment on the observation is that NASA is not saying it's the wrong architecture but that the architecture can't be funded by the U.S. alone. It needs to stay positive; otherwise they may think we are saying that there is something wrong with the architecture.
- Mr. Cuzzupoli's recommendation is that NASA should develop a new launch vehicle main (expendable) engine by a U.S. contractor that will provide sufficient thrust. This engine must support a launch vehicle schedule sufficient to lift 100mT.
- The committee feels strongly about elevating the HRP to its own directorate and developing this as a recommendation.

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